Short manual for deployment of calibration sources into KamLAND

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Introduction

KamLAND source deployment system

Z-axis deployment system served to positioning of calibration sources in particular place inside of the KamLAND (on Z-axis only).

Deployment system includes:

1) cable on a spool to which calibration source attached for deployment;
2) step motor with controller to move cable in particular Z;
3) calibration computer with software to manipulate by deployment system;
4) gloves box (GB) inside of which main part of calibration system located;
5) N_2 gas system for GB purification;
6) 2 gate valves (GV) connecting (isolating) GB from the detector;
7) light shielding;
8) calibration tent with radon less air supply

Deployment logic is quite simple:

A source attached to the cable of the deployment system moved to particular position into detector. Since originally source located in the GB, that box has to be properly purified before it can be opened to the detector. Since PMTs are extremely sensitive to visible light, we also need light shielding on the GB window (or PMTs' HVs have to be OFF when gate valves opened). To connect GB with the detector one has to open gate valves and to close its when calibration finished.

Operator of deployment system has to have good knowledge about:

1) Manipulation of deployment system in manual and computer mode, how to introduce source offset and how to deploy a source in particular Z with respect to balloon center.
2) Calibration computer location and connections between controller, calibration computer and computer which you use in time of calibration
3) Operation of gas system (include oxygen monitor)
4) How to open/ close gate valves and even more important when it's possible to open and close.
5) How to control critical source positions independently from computer.
6) How to make light shield protection.
7) HV operation.
8) How to start/stop calibration run. Control of data taking. With whom contact and what to do in case of trouble with trigger or FBE.

For who is that manual: that manual is mainly prepared for help to operator of deployment system to refresh their memory after long time interval between deployments.

The manual has no aim to teach anybody about how to perform calibration deployment. It's impossible to perform safety source deployment with using that manual only.

Logical structure of that manual is follows of steps in time of usual calibrations.

In beginning I would like to remind main safety issue:

The main danger in time of a calibration is to loose a radioactive source in KamLAND, that will be destroy the Detector. That is not fixable problem.

To avoid that problem: NEVER OPERATE GATE VALVES IF YOU ARE NOT **100%** SURE THAT SOURCE AND ALL PARTS OF THE DEPLOYMENT SYSTEM ARE OUT OF THE DETECTOR. YOU HAVE TO CHECK IT VISUALLY!!! YOU HAVE TO CHECK IT BEFORE ANY OPERATION WITH GATE VALVES, REGARDLESS OF TIME, ANY OTHER PROBLEMS OR ANYTHING ELSE. YOU SHOULD NOT TRUST COMPUTER IN THAT CASE!!! ELECTRICAL

PARTS OF THE GATE VALVES HAVE TO BE LOCKED BETWEEN OPERATIONS. YOU HAVE TO CHECK EVERYTHING DOUBLE BEFORE START TO OPEN/CLOSE VALVES. ELECTRICAL PARTS OF THE GATE VALVES CAN BE IN ON POSITION ONLY WHEN DEPLOYMENT SYSTEM IS IN THE GB (visual check required).

I. What we are suppose to do before deployment

a) Deployment plan, when, who, what source, what position, what has to be done before

It's quite important that any calibration to be well planned.
Especially next is important: Source you will use, where that source is, who used it last, any problem with it, what is source activity on day of deployment and if DAQ/trigger recent conditions required adjustment of source data taking conditions.
Please make exact plan about positions you want to deploy the source, estimate time you will need for that. Refresh your memory about source offset and calculate absolute Z for deployment code. You need to plan with coordinators on the site your activity. Also, please clearly inform shift about your plans.

b) Recent condition of the deployment system

Please check if deployment system is still same as it was last time. Please check connections between all parts of the deployment system. If calibration computer (KAMCALPC1) is OFF, turn it on.

Username: Administrator
Password: kamland

Check visually for any clear problems with deployment system cable. Try to move the system in manual and then computer mode (be careful in such exercise, always have visual contact with deployment system in time of that work).

d) Recent condition of gas system and the GB, problems, what else is in the GB on the moment (how to remove, who is responsible)

If there is any recent problems with gas leak into GB? Who worked last and what kind of work?
If any work for GB improvement was performed recently be especially careful!
Check pressure port setting on N_2 supply line. Adjust it if necessarily. In the present time we set it to be 2 psig.
Check for any unusual objects inside of the GB. (Especially after j-laser work, search for nuts)
If something found, try to find out what is a purpose of it, why it is in the GB, who put it there. Coordinate it with coordinators on the site.

e) DAQ operation, HV operation

Settings for calibration runs are different from normal data taking.
If any updates in daq or trigger happened recently and there are no problems for normal data taking it still does not means that calibration data taking will have no problem. Please check it with trigger/FBE experts. Check with HV experts about HV operation and possible problems.

f) Nitrogen availability

You will need N2 for purification of GB system.

We are also continuously supplying N_2 into chimney region. That has higher priority for N_2 distribution. Usually, when we have lack of N_2 amount we need to wait 1 week or more for new delivery.
Please check in advance with coordinators on the site that N_2 for calibration purpose is available.

g) Radon condition in the mine, dome, deployment clean hut

For proper planning of purification of the GB, you have to know recent radon concentrations in the dome and calibration clean hut. There is radon monitoring system developed by Tohoku group (did not worked properly, as in beginning of May 2004). Please contact j-coordinator on the site for any future details.
2 mobile radon monitors are also available. Manual for them can be found on the shelf in the control room.

h) Clean room recent condition (include check of radon less air supply)

To check dust level in the calibration clean room is especially important in case when you plan to put/take out something to/from the GB.
Please check radon less air supply into calibration hut, that is important for your safety and for low radon level around chimney. If calibration hut was not used for long time, please check O_2 concentration inside before work there. Please always take in mind that your safety is only in your own hands.

II. Preparation to deployment (purification of the GB)

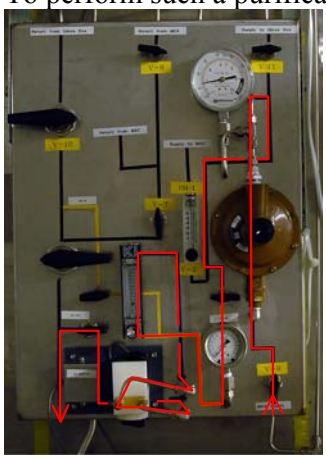
Few short remarks in beginning:
As you know gloves box (GB) system consists from 3 chambers: GB itself, transfer box (TB) and region between 2 gate valves (GV) (so called M5C region). Each region has N_2 supply and return pipes. That provides great flexibility for proper purification of the GB by nitrogen.
Way of purification has to be chosen to provide circulation in all chambers for time sufficient to reduce radon concentration to lowest possible level.
There is nothing magic in way we are doing it now. That can be modified if somebody will propose better way to do it or if present GB gas leak problem will be fixed.
Method we used so far provided low contamination of the Detector by radon in time of calibrations, so I will describe it here as recommended one for the present time.

a) Check if GB system isolated from the detector volume (16 inch GV check)

Be sure that no other calibration activity is going in the same time. It will take not so much of your time to enter into calibration hut and check it visually.
Check that operation of 16 inch GV is blocked (red button).
Use key to switch power of 16 inch GV ON. You can see indication that GV closed.
If something unexpected is found, for example one indicator is not working, or there is indication that GV is open, or anything else, problem has to be understood and fixed before any other calibration activity. Be especially careful in case if you will find GV opened when it supposed to be closed. Check first with shift, other calibration group representative on site, coordinators on the site that there is no any other calibration activity is going on. Don't try just close GV without double check!
After check done – switch power OFF, return key on usual place.

b) Prepare oxygen monitor

You will need to use O_2 monitor to check how well you did GB purification and if there are no any new problems with the gas leak into GB.
Work of O_2 monitor is based on using chemical reactions with oxygen in a cell. Due not 100% isolation of the cell from outside air, oxygen concentration in cell between calibrations separated by long time can be same as in the air. That means that we need to purify it before using. Time of such purification depends on time from when it was used last time. I recommend not less then 1 h per 1 week from last use and long (up to few days) purification once per 2 months.
To perform such a purification use direct N_2 supply to the oxygen probe (see picture).



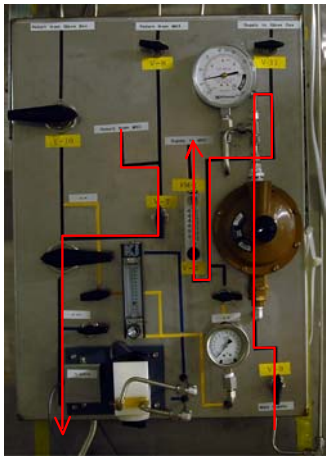
Open return from O_2 monitor
Open main supply
Open supply to O_2 monitor, check pressure
Adjust flow rate

To stop: close all opened supplies (include flow meter), close all opened exhausts.

c) Check baseline level of oxygen meter

Absolute measurement of oxygen concentration required calibration of O_2 monitor with calibrated gas under same pressure/flow rate conditions with measurements. We don't have such possibility in our system, so we have to know a baseline for our measurement. For that we can measure oxygen concentration in supply line. As you know, flow rate through the oxygen probe in time of measurement of oxygen on exhaust line is defined by supply which in own turn mainly regulated to keep pressure in the GB on relatively low level. Usually under such a conditions flow rate through oxygen probe is about 20 in units of scale on oxygen probe flow meter (about 1.5 l/mim). Please use same flow for baseline measurements. Please take in mind that result of baseline measurement will be different from true baseline in time of measurement on exhaust line since: 1) pressure is sufficiently different; 2) usually there is time gap in more then 10 h between 2 measurements. In that time oxygen probe can be slightly affected by external air.

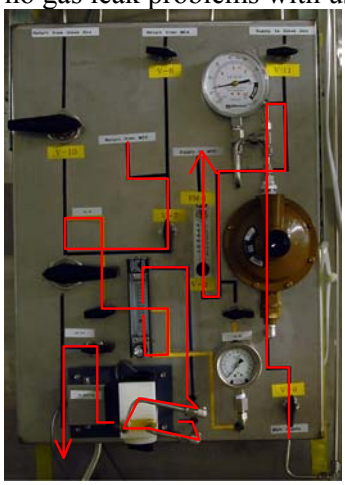
d) M5C region only purification
That purification is part of effort for better circulation of N_2 in all chamber of the GB.



Please see picture for better understanding:

Be sure both GVs are closed
Open main return and return from M5C region
Open main supply
Open and adjust supply to the M5C region by flow meter
Usually we supply 10 scfh (5l/min). Volume of the M5C region is about 12 l. Unhappily (for that case), supply and return pipes entries into M5C region are located relatively close to each other, so circulation of N_2 inside of that region is slow.

You can check how well you purified M5C region and if that region (more close to the Detector) has no gas leak problems with using of oxygen monitor (please see next picture).



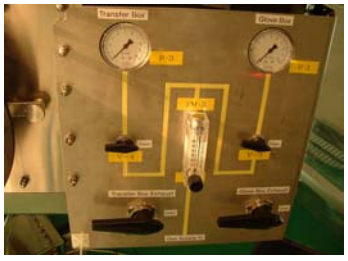
Assuming you purified M5C region just before:
Stop supply by flow meter
Close main exhaust
Connect return line with oxygen monitor line
Completely open O_2 flow meter (it is exhaust line now!)
Open return line from O_2 meter
Re-start supply into M5C region. Use flow rate at ~2 scfh.
Switch monitor ON.

To stop:
Switch monitor OFF.
Stop supply by adjustment of flow meter to 0.
Close return from O_2 meter
Close supply to O_2 meter and flow meter on that line.
Open main return for 1-2 min (to reduce pressure in the M5C region)
Close return from M5C region and main return.

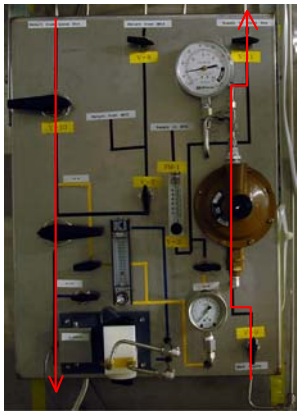
Comment: You don't need to make complete purification of M5C region on first stage since later we will purify it together with other regions one more times.

e) GB only purification

Usually for regular calibrations (in which we don't open GB to outside) that stage help to remove some particles from the GB (dry LS) and for better circulation in all volumes. Usually we continue it for few hours (1-2).
In principle, at once problem with leak at rotary stage will be fixed, we can return to purification scheme in which we completely purify M5C region first, then only GB.



Be sure that 6 inch GV closed, gloves covers attached properly.
Open main return and return from the GB on the lower gas panel
Open return from the GB on upper gas panel
Open main supply and supply to the GB on the lower gas panel
Open supply to the GB on the upper gas panel
Adjust supply by flow meter.
Usually on that stage we supply about 10-12 scfh (5-6 l/min). Volume of the GB is about 0.3 m^3.

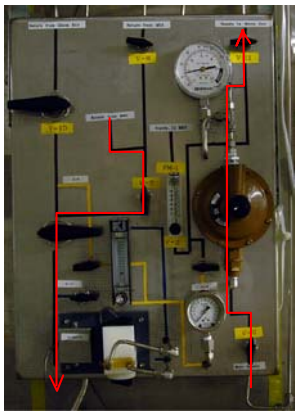


Please control pressure in the GB. If pressure increase continuously – it means some valve on exhaust line is still closed. In such situation close supply, check return line, then start over.

To stop:
Stop supply by adjustment of flow meter to 0.
Close all valves on supply line (both panels).
Close all valves on return line (both panels).

f) GB->M5C region purification (open 6 inch GV!)

That is main purification using for the moment. The reason for that is in a gas leak on the rotary stage part. To provide proper gas circulation in that region we need to use supply in the GB and return from M5C region (opposite direction is also possible, but I recommend to use GB->M5C one).
To start that gas circulation we need to connect GB and M5C region, that means to open 6 inch GV. There is also light shield cover on the 6 inch flange in the GB. Please move it slightly to make a path for the gas.



Be sure that 6 inch GV opened, gloves covers attached properly.
After 6 inch opened put red label on the white board
Open main return and return from the M5C region on the lower gas panel
Open main supply and supply to the GB on the lower gas panel
Open supply to the GB on the upper gas panel
Adjust supply by flow meter (upper panel).
Usually we supply about 8 scfh (4 l/min). Volume of the GB is about 0.3 m^3. Under such conditions we need 12.5 h of supply to purify the GB by 10000 times (10 volumes changed). Usually we continue supply over night (16 h or more), to be sure that purification done even with not ideal gas circulation.

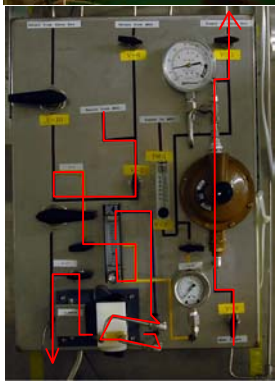
Please control pressure in the GB. If pressure increase continuously – it means some valve on the exhaust line is still closed. In such situation close supply, check return line, then start over.
Since resistance of return line in M5C region is higher then in GB (due smaller diameter of the pipe) pressure in the GB will be grow up to 5-6 inch H_2O. Be sure that it stabilized on that level (you have to wait 10-15 min).

To stop: Stop supply by adjustment of flow meter (upper panel) to 0. Close all valves on supply line (both panels), close all valves on return line.

III. Deployment

In that chapter procedures performed on deployment day are described. That means that GB system already purified, as it explained in chapter II.

a) Check if purification done correctly (and radon level on time of deployment)



We use O_2 monitor to check if our efforts by purification of the GB were successful.

(Assuming that you continue GB->M5C purification started night ago.)

Stop supply into the GB by adjustment of flow rate to 0 by flow meter on the upper panel.
Close main return on lower panel.
Open return from O_2 monitor, open completely flow meter of oxygen monitor, connect return line with O_2 monitor line.
Start O_2 supply by adjustment of flow by flow meter on the upper panel.
Be careful, resistance of return line in such configuration is extremely high. You have to control flow very carefully to keep pressure on below 5-6 inch H_2O level.

Switch O_2 monitor ON.
Wait few minutes, then record result of measurement.

To stop:
Switch monitor OFF.
Stop supply into GB by adjustment flow rate to 0 by flow meter on the upper panel. Close all valves on the supply line (both panel).
Close return line from O_2 monitor.
Disconnect O_2 line from return line. Close O_2 monitor flow meter.
Open main return line for 1-2 min (to release pressure in the GB).
Close return from the M5C region and main return.

If result of measurement is usual proceed to next step.

b) zero source position

Visually check if source is in the maximal upper position. If not move it in that position in manual mode of deployment system.
Check if small cover plate is removed from 6 inch flange.
After operation of the deployment system in manual mode reset it by switching ON/OFF (source has to be in the upper position at that moment!)

c) Prepare deployment system for operation. Check if deployment system response is correct.

Open VNC viewer connection to KAMCALPC1
Connect to vnc server: KAMCALPC1:0 password: mozumi01
Start "Shortcut to ZaxisSC8800E_ver01a.exe.exe"
Enter your name and password: mozumi01
Check that all fields presented target and present positions are 0. Source position in detector coordinate has to be 13.372.
Switch deployment system ON, change operation mode to computer.
Click expert On/Off button and introduce source offset (you will see that source position in detector coordinate changed respectively) Absolute position of the deployment system has to be unchanged! **Positioning of deployment system is based on absolute scale and independent from source offset!**
Click expert On/Off button.

Now you need to check if response of deployment system on your command is correct.
Do not ignore that step!
Introduce -0.05 m in the target field. Check if control panel (left lower corner) has same value. If not try to use UpdateBuffer button.
Click UnLock button. Click Go. If system moved longer then you expected, click Stop button.
If in previous step system moved as expected, then move system to -0.48 cm. That step need to put light shield protection. Click Locked button. Introduce new target. Check it. Click Unlocked. Click Go. Control position of the source with indicators or visually. If system moving longer then you expected stop it. You need to continue click Go button few times until source will reach desire position with accuracy at 1 mm. After that Go button will be disappeared.
After that system is checked and ready for deployment (do not switch deployment system OFF until end of deployment!).

d) Prepare DAQ

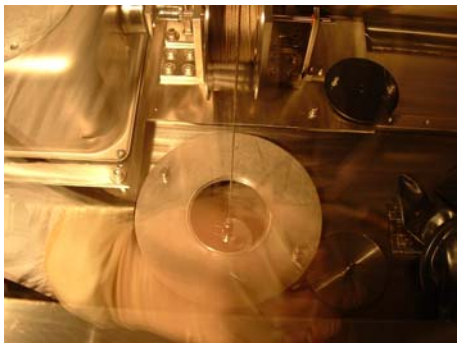
Open vnc connection to zoe1 computer.
VNC server: zoe1:0 password: kamland
Check current run condition. You can also prepare kinoko for next run.

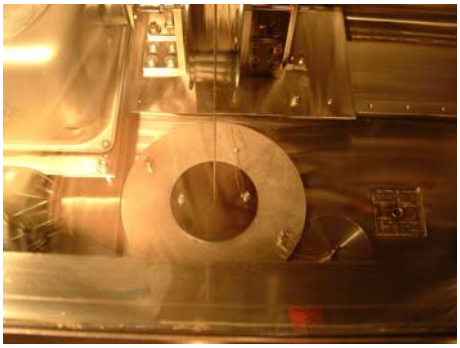
e) Start tiny supply of nitrogen into M5C region

Due leak in the GB we continuously supply nitrogen in M5C region during deployment.
Procedure is exactly same as in case of M5C region purification. Flow rate – as smaller as possible (below of 1 l/min). Pressure in the GB under that flow rate should be bellow of 1 inch of H_2O.

f) Light shield protection, special light in the GB region OFF, be sure that fish line of the black disk can not be catch by deployment system

At once pressure is bellow of 1 inch of H_2O you can remove gloves' protectors and put black disk in the center of the 6 inch flange as shown on pictures bellow.


Source at -0.48 m position


Black disk is on

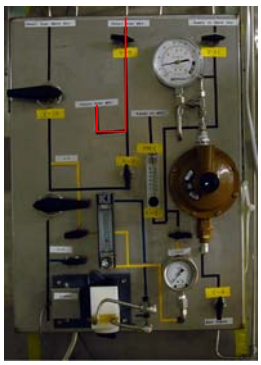
Be sure that fish line of the black disk can not be catch by any moving part of the deployment system.
Put GB window cover plate and additional cover on.
Switch light in the calibration hut off.

g) Make gas buffer with gloves of the GB

Attach GB gloves protectors. Screw bolts in by 1-2 turns only, so you will have a buffer for case of high pressure difference between the GB and the chimney.

h) Check one more times if everything done correctly, check 6 inch GV open
Stop normal run, inform shift that you will start calibration

i) Connect M5C and chimney region by small pipe, wait a little



The step required to avoid pressure shock wave in case of pressure difference between the GB volume and the chimney.
Connect M5C and chimney region by open V8 valve on the lower gas panel.
You can check pressure in the chimney by pressure meter (one check of which included in shift check list).

j) Open 16 inch GV, check it, when done, switch power of the motor off. Close valve on the pipe connected M5C-M5A region

Before open 16 inch GV, stop and think one more times if everything is ready to connect detector and the GB.
Then switch motor power ON.
Unlock red button.
Push Open button.
After gate valve is opened you will see indication of that.
Lock red button.
Check open indicator few times by turning power On/Off.
Turn power Off and remove the key.
Put red label 16 inch GV opened on the white board.
Close valve on the pipe connected M5C and chimney region

If indicator GV opened is not On after GV opened you should not continue calibration until source of the problem is found and fixed.

k) Start deployment

After 16 inch GV opened everything is ready to deploy the source in target position.
Go to deployment program.
Click Lock button.
Introduce target position (take into account source offset and that absolute target position is position of the deployment system without source)
Check if target you introduced and target in control window are the same.
Click UnLock button and Go button.
Be ready to stop deployment, especially 2 first m in case you will hear any strange noise.

l) Prepare DAQ to start new run

You can do it until source moving to it target.
Introduce source type and acquisition mode properly. Put source position in comments.

m) At one source deployed, wait a little then start calibration, check 5 inch PMT rate

You will need to click Go button few times until source will reached desire position. After that Go button will be disappeared. If source offset is correct and absolute position was calculated correctly you will see correct source position with respect to the balloon center in field “present source position in the detector coordinate” (low center).

You can start calibration run soon after source deployed. After pedestal taking finished, check 5 inch PMT rate to detect if light leak exist.
Check Nsum spectra, data flow from each FBE crate, HV and all other parameters as for usual data taking. Availability information in some windows depends on trigger parameters of calibration run. (don’t expect to see information about prompt nsum if no prompt triggers taking)

n) Stop calibration, move source in upper position

You probably need decide in advance how many source events you need, what positions you want to study.

At once calibration data taking is completed start moving the source out at -0.01 m position (remember about black disk).

Avoid any touch of the GB in that time. If GB is touched by accident stop moving immediately. Wait until swinging is stopped. Then restart moving again.

o) Upper position check

We can not trust information provided by computer to make a conclusion if source is in the upper position or not.
We need to have an independent control of it.
THAT IS MORE CRITICAL PART OF CALIBRATION!!!

When source is in the upper position by information from computer, control it visually with IR camera or by hand touch.
If you are not 100% sure about source position, switch HV OFF and control it visually through GB window.

p) Close 16 inch GV, stop nitrogen supply in the M5C region

After source reached to upper position and you made independent check of it, then you can close 16 inch GV.
Switch power On.
Unlock red button.
Think one more times.
Push close button.
At once GV is closed you will see indication of that.
Lock red button.
Check gate valve closed indicator few times by switching motor On/Off.
Switch motor off.
Remove the key.
Remove 16 inch red label from the white board.
After 16 inch GV closed you can terminate tiny nitrogen supply into M5C region.

r) New run

You can construct for new run until source moving up if free time is available. First run after calibration is background run. Use same as for Hg-203 settings to take it.
Before start background run switch deployment system OFF, switch IR camera system OFF

Start background run and then normal run, after normal run started inform shift that calibration is finished.

IV. After deployment

a) Check O_2 in the GB (don't forget to fix gloves protection before that)

That step is exactly same as when we check O_2 before calibration.

b) Return gas system in original condition

That means that all valves on supply line are closed as well those on return line.

c) Close 6 inch GV, be sure that source is in the upper position when you do it.

At that time you can control that directly by looking in the GB window. Remove 6 inch valve red label from the white board.

d) Return source to zero position

Due black disk, we can not move source with it at zero position.
Remove black disk first. Then move source in the upper position in the manual operation mode.
Before remove gloves protector be sure that pressure in the GB is bellow of 1 inch of H_2O.
After operation is done put gloves protectors on place.
Switch deployment system OFF.
Quit from deployment system program:
Click Quit button first, then click exit in File menu option. (such procedure is need to save record about calibration in log file)
Close VNC connection to daq and to calibration computer.

Switch light in calibration hut off after work is finished.

e) Document the deployment

Make a clear record in e-logbook about calibration run(s) you took with information about source type, source position(s), any problems, observations, ….

V. Everything above in short format:

1. *Before deployment*
    a) Deployment plan, when, who, what source, what position, what has to be done before
    b) Source, offset of the source
    c) Recent condition of the deployment system
    d) Recent condition of gas system and the GB, problems, what else is in the GB on the moment (how to remove, who is responsible)
    e) DAQ operation, HV operation
    f) Nitrogen availability
    g) Radon condition in the mine, dome, deployment clean hut
    h) Clean room recent condition (include check of radon free air supply)
2. *Preparation to deployment*
    a) Check if GB system isolated from the detector volume (16 inch GV check)
    b) Prepare oxygen monitor
    c) Check baseline level of oxygen concentration
    d) M5C region only purification
    e) GB only purification
    f) GB->M5C region purification (open 6 inch GV!)
3. *Deployment*
    a) Check if purification done correctly (and radon level on time of deployment)
    b) Check if deployment system response is correct, introduce source offset.
    c) Prepare DAQ
    d) Start tiny supply of nitrogen into M5C region
    e) Light shield protection, special light in the GB region OFF, be sure that fish line of the black disk can not be catch by deployment system
    f) Make gas buffer with gloves of the GB
    g) Check one more times if everything done correctly, check 6 inch GV open
    h) Stop normal run, inform shift about
    i) Connect M5C and M5A region by small pipe, wait a little
    j) Open 16 inch GV, check it, when done, switch power of motor off. Close valve on pipe connected M5C-M5A region
    k) Start deployment
    l) Be ready to stop deployment, especially 2 first m
    m) Prepare DAQ to start new run
    n) At one source deployed, wait a little then start calibration, check 5 inch PMT rate
    o) Stop calibration
    p) Start moving source out at -0.01 m position
    q) Switch IR camera system in the GB ON
    r) Construct for new run if free time is available
    s) When source in the upper position, control it visually with IR camera or by hand touch
    t) Close 16 inch GV, stop nitrogen supply in the M5C region
    u) Switch deployment system OFF, switch IR camera system OFF
    v) Start background or normal run, after normal run started inform shift people
4. *After deployment*
    a) Check O2 in the GB (don't forget to fix gloves protection before that)
    b) Return gas system in original condition
    c) Close 6 inch GV, be sure that source in the upper position when you do it
    d) Return source in original condition
    e) Document the deployment
    f) Drink bear